

## Description of a new species of *Simulium* (*Nevermannia*) (Diptera: Simuliidae) from Japan

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**Abstract:** A new black-fly species, *Simulium* (*Nevermannia*) *artum* sp. nov., is described based on male, female (dissected out of pupa), pupal and larval specimens collected from Tochigi and Hokkaido, Japan. This new species is assigned to the *vernum* species-group and appears to be most closely related to *S. subcostatum* (Takahasi) in that it has a combination of the following characters; katepisternum bare, female genital fork without any projection directed anteriorly on each arm, pupal frons with three long trichomes on each side, cocoon simple, and larval rectal organ with 0-2 secondary lobules on each lobe. However, *S. artum* is easily distinguished from *S. subcostatum* and other known related species by the pupal gill with four long slender filaments usually arising together at the same level from the very short common basal stalk.

Key words: black fly, new species, Simuliidae, *Simulium*, *Nevermannia*, *vernum* species-group

Fourteen species and one subspecies of the subgenus *Simulium* (*Nevermannia*) Enderlein are known to exist in Japan, of which nine species and one subspecies are placed in the *vernum* species-group: viz. *S. acmeria* (Ono), *S. boldstemta* (Ono), *S. bonninese* (Shiraki), *S. larvipilosum* Okazawa, *S. onoi* Sato and Takaoka, *S. rebunense* (Ono), *S. subcostatum subcostatum* (Takahasi), *S. subcostatum koshikiense* Takaoka, *S. uchidai* (Takahasi) and *S. uemotoi* Sato, Takaoka and Fukuda (Crosskey and Howard, 1997; Sato et al., 2004). We collected a new species of this species-group from Tochigi in Honshu Island and Hokkaido, which is conspecific to *Eusimulium* sp. 1 reported by Orii et al. (1969), *E.* sp. by Onishi and Uemoto (1970), *S. (E.)* sp.-Y by Saito and Kanayama (1988) and Saito et al. (1995a), and *S.* sp. Y by Saito et al. (1995b).

This is described as a new species based on male, female (dissected out of pupa), pupal and larval specimens collected from Tochigi and Hokkaido, Japan. The morphological features and their terms used follow Takaoka (2003). Holotype and paratype specimens are deposited in the Department of Infectious Disease Control, Faculty of Medicine, Oita University.

### *Simulium* (*Nevermannia*) *artum* sp. nov.

*Eusimulium* sp. 1: Orii, Uemoto and Onishi, 1969: 8-9 (head capsule of larva).

*Eusimulium* sp.: Onishi and Uemoto, 1970: 133 (brief descriptions of female, male, pupa and larva).

*Simulium* (*Eusimulium*) sp.-Y: Saito and Kanayama, 1988: 46; Saito et al., 1995a: 70.

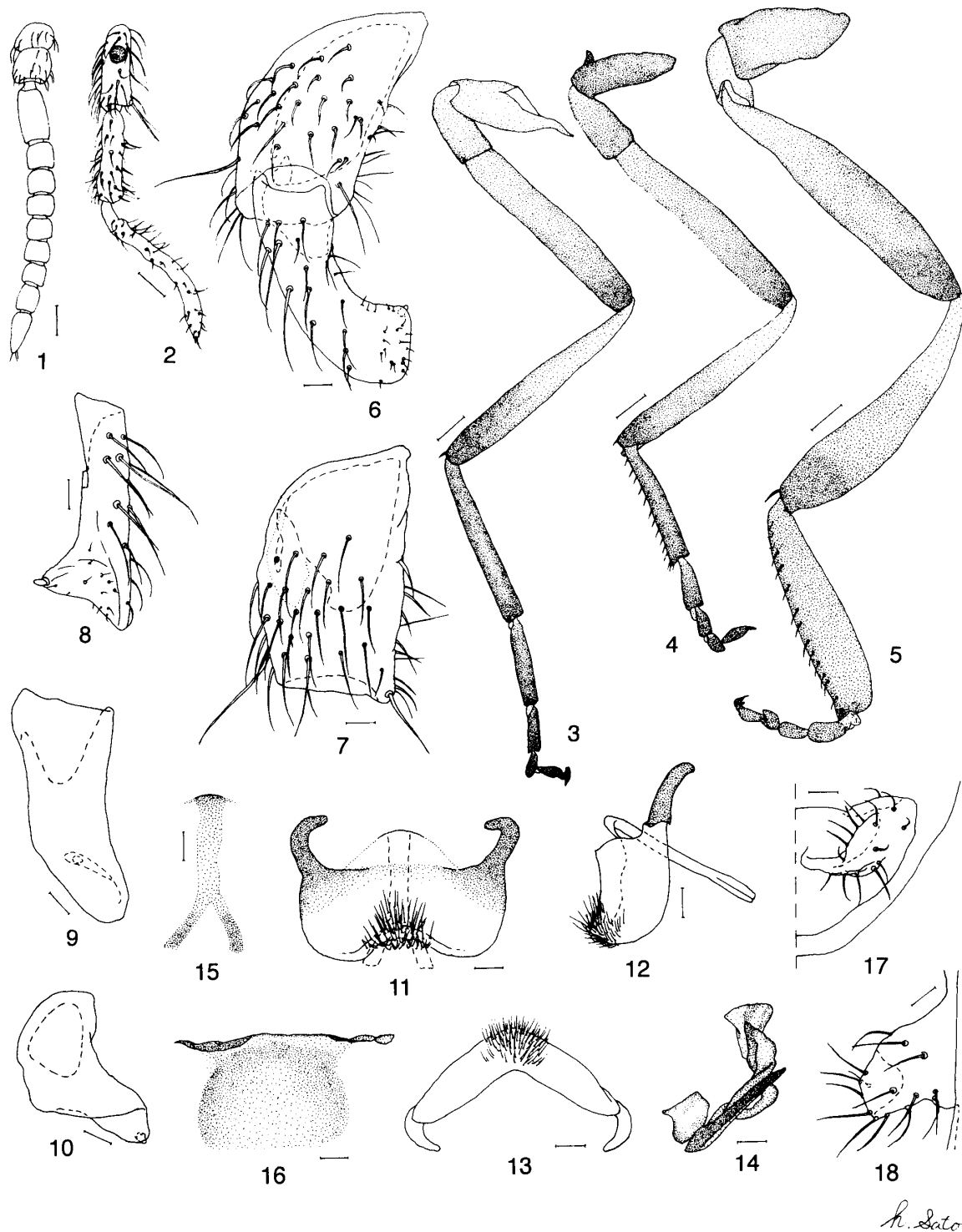
*Simulium* sp. Y: Saito et al., 1995b: 310:

1996: 382.

**DESCRIPTION. Male.** Body length 2.5 mm. **Head.** Slightly wider than thorax; holoptic; upper eye consisting of 20 vertical columns and 22 horizontal rows of large facets. Face and clypeus blackish-brown, white pruinose; clypeus moderately covered with dark long hairs and yellow fine hairs except medial portions bare. Antenna (Fig. 1) composed of 2+9 segments, dark brown except scape and pedicel light to medium brown and base of 1st flagellar segment yellow; 1st flagellar segment elongate, 2.3 times as long as 2nd one; 9th flagellar segment also somewhat elongate, 1.8–1.9 times as long as 8th one. Maxillary palp (Fig. 2) with 5 segments, light to medium brown, proportional lengths of 3rd, 4th, and 5th segments 1.0 : 1.0–1.1 : 1.9; sensory vesicle small and globular, ca. 0.2 times as long as 3rd segment, with medium-sized opening. **Thorax.** Scutum blackish brown (except anterolateral calli light brown), not shiny (except wide areas along both lateral margins and prescutellar area shiny at certain angles of light) and densely covered with whitish-yellow recumbent short hairs interspersed with several dark upright long hairs on prescutellar area. Scutellum dark brown, with dark upright long hairs as well as whitish-yellow short hairs. Postnotum dark brown, bare, shiny at certain angles of light. Pleural membrane bare. Katepisternum bare. **Legs.** Foreleg (Fig. 3): coxa yellow; trochanter light brown with base yellow; femur medium to dark brown; tibia medium to dark brown with outer surface of basal 2/3 widely yellowish; tarsus dark brown. Midleg (Fig. 4): coxa medium to dark brown; trochanter medium brown with base yellow; femur light brown on base, gradually darkened toward apex with apical cap dark brown; tibia yellowish on basal 2/5, light to medium brown on the rest with apical cap dark brown (its border not well defined); tarsus dark brown. Hind leg (Fig. 5): coxa medium to dark brown; trochanter dark yellow; femur medium brown with base dark yellow and apical cap dark brown; tibia dark yellow on basal 1/3, medium brown on the rest with apical cap dark brown (its border not well defined); tarsus medium brown; basal 1/3 of 2nd tarsal segment dark yellow; basitarsus ca. 4.3 times as long as its greatest width, and ca. 0.9 and ca. 0.9 times as wide as the greatest width of hind tibia and femur, respectively;

calcipala ca. 0.96 times as long as wide, and ca. 0.34 times as wide as the greatest width of basitarsus; pedisulcus well developed. **Wing.** Length 2.3 mm. Costa with dark spinules and hairs. Subcosta bare. Basal portion of radial vein with dark hairs;  $R_1$  with dark spinules and hairs on dorsal surface;  $R_2$  with dark hairs on ventral surface. Hair tuft at base of radial vein dark brown. Basal cell absent. **Abdomen.** Basal scale dark brown to brownish black with fringe of ochreous to light brown long hairs. Dorsal surface of abdomen dark brown to brownish black, not shiny, covered with dark short hairs. **Genitalia.** Coxite (Figs. 6 and 7) in ventral view ca. 1.7 times as long as wide. Style (Figs. 6 and 7–10) boot-shaped, about 1.0–1.1 times as long as coxite, twisted inwards, with apical spine. Ventral plate (Figs. 11–13) in ventral view lamellate, transverse, much shorter than wide, setose medially, with posteromedial depression; arms well sclerotized, divergent, then well convergent apically; Paramere (Fig. 14) with 1 large hook. Aedeagal membrane moderately covered with microsetae. Median sclerite (Fig. 15) forked apically. Dorsal plate (Fig. 16) well formed, thick; abdominal segment 10 (Figs. 17 and 18) with 9 short setae (of which 1 seta is located ventrally, while the others laterally) on each side. Cerci (Figs. 17 and 18) rounded, each encircled with 6 setae.

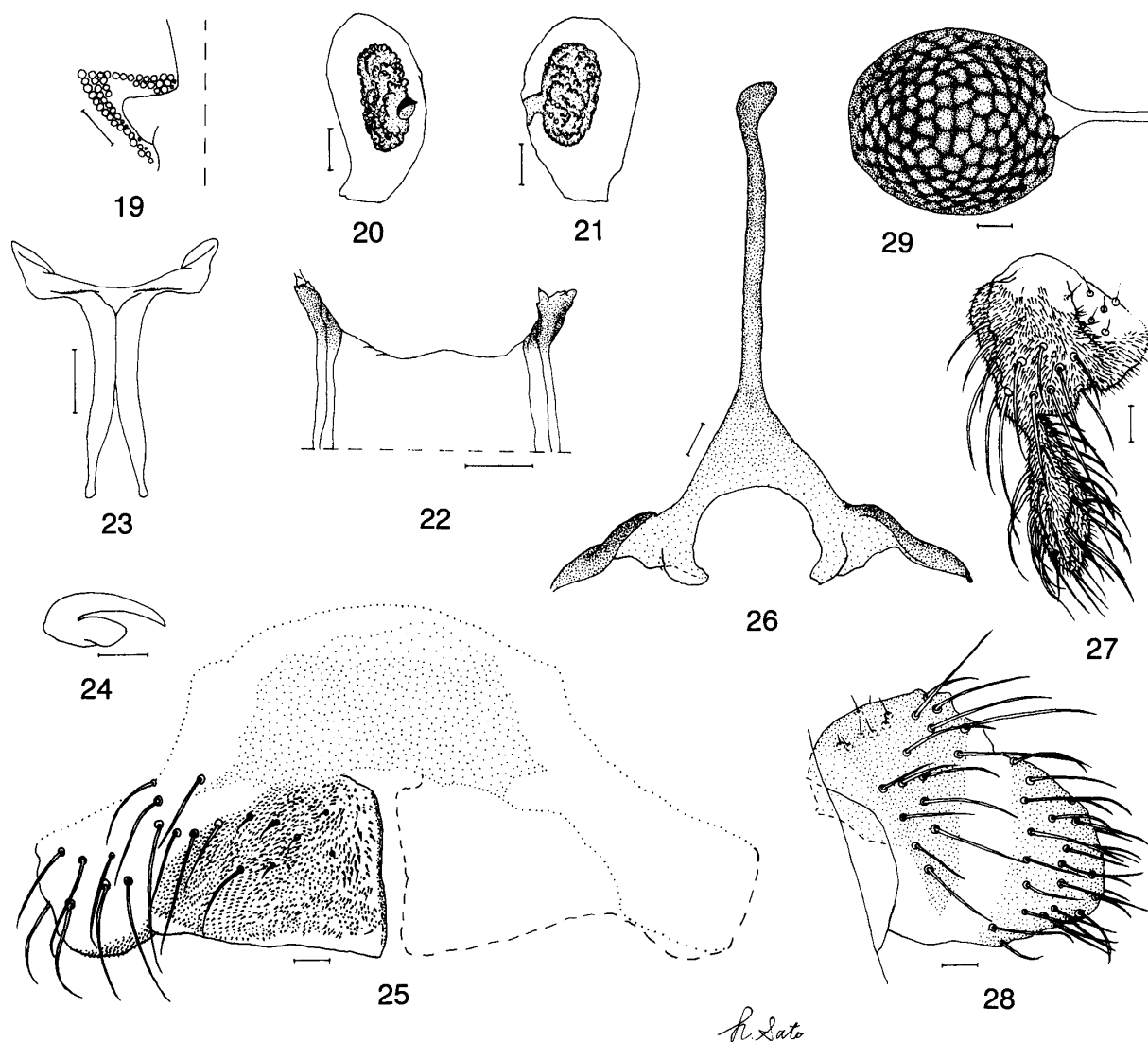
**Female** (dissected out of pupa). Body length 3.2–3.4 mm. **Head.** Frons densely covered with light-colored fine hairs. Frontal ratio 1.7 : 1.0 : 1.9; frons-head ratio 1.0 : 4.2. Fronto-ocular area (Fig. 19) well developed, directed laterally and upwardly. Clypeus densely covered with light-colored fine hairs interspersed with several dark-colored hairs on each side. Labrum 0.7 times as long as clypeus. Antenna composed of 2+9 segments; 1st flagellar segment somewhat longer than 2nd one, and 9th flagellar segment also somewhat longer than 8th one. Maxillary palp composed of 5 segments, of which 3rd segment (Figs. 20 and 21) somewhat enlarged; sensory vesicle elongate, 0.6 times as long as 3rd segment, with medium-sized opening. Lacinia with 11 inner and 15 outer teeth. Mandible with 30 inner and 15 outer teeth. Cibarium (Fig. 22) simple. **Thorax.** Scutum medium brown (except anterolateral calli light brown), shiny and whitish-grey pruinose along lateral margin and on prescutellar area at certain angles of light, densely covered with whitish-yellow recumbent short hairs as well as several



Figs. 1-18. Morphological characters of male of *Simulium (Nevermannia) artum* sp. nov. 1, antenna; 2, maxillary palp; 3, foreleg; 4, midleg; 5, hind leg; 6, coxite and style (ventral view); 7, coxite (ventrolateral view); 8-10, styles (8, lateral view; 9, ventrolateral view; 10, end view); 11-13, ventral plates (11, ventral view; 12, lateral view; 13, end view); 14, right paramere (end view); 15, median sclerite; 16, dorsal plate; 17 and 18, cerci (17, end view; 18, lateral view). Scales. 0.02 mm for Figs. 6-18; 0.1 mm for Figs. 1 and 2; 0.2 mm for Figs. 3-5.

same colored upright long hairs on prescutellar area. Scutellum dark yellow with whitish-yellow short and long hairs. Postnotum

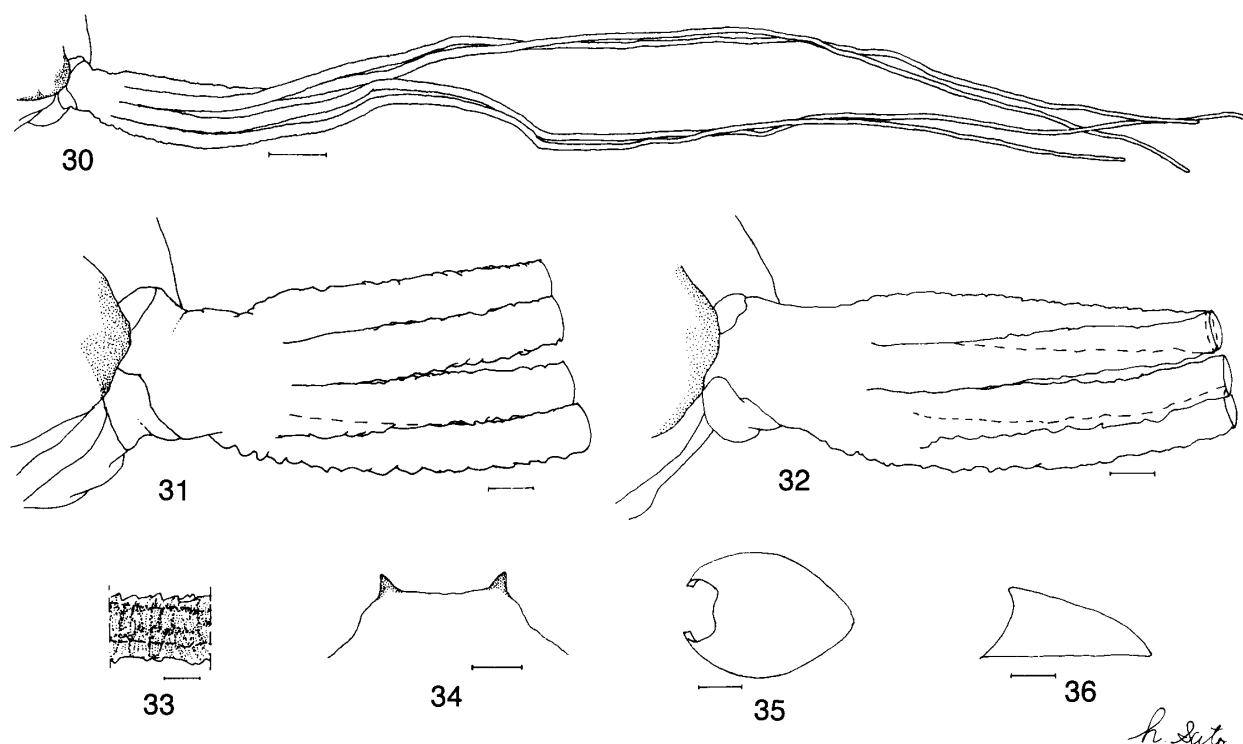
medium brown, shiny, thinly whitish-yellow pruinose at certain angle of light and bare. Pleural membrane bare. Katepisternum longer



Figs. 19-29. Morphological characters of female of *Simulium* (*Nevermannia*) *artum* sp. nov. 19, fronto-ocular area; 20 and 21, 3rd segments of maxillary palp (20, front view; 21, lateral view); 22, cibarium; 23, furcasternum; 24, claw; 25, sternite 8 and ovipositor valves *in situ* (ventral view); 26, genital fork; 27 and 28, paraprocts and cerci (27, ventral view; 28, lateral view); 29, spermatheca. Scales. 0.02 mm for Figs. 25-29; 0.04 mm for Figs. 20-22; 0.1 mm for Figs. 19, 23 and 24.

than wide, medium to dark brown, shiny at certain angle of light and bare. Furcasternum (Fig. 23) with wide arms each projection directed downwards. **Legs.** Foreleg: coxa yellow; trochanter light brown; femur and tibia pale except apical cap medium brown; tarsus medium brown, with moderate dorsal hair crest; basitarsus somewhat dilated, 6.2 times as long as its greatest width. Midleg: coxa light to medium brown; trochanter dark yellow; femur and tibia pale except apical cap medium brown; tarsus medium brown, although basal 1/3 somewhat lighter. Hind leg: coxa light brown; trochanter dark yellow to light brown; femur and tibia pale except apical cap medium

brown; tarsus light to dark brown; basitarsus slender, nearly parallel-sided; calcipala 1.3 times as long as wide; pedisulcus well developed. All tarsal claws (Fig. 24) with large basal tooth 0.55 times as long as claw. **Wing.** Costa with dark spinules and dark hairs except basal portion with yellowish hairs. Subcosta fully haired on ventral surface. Basal portion of radial vein fully haired;  $R_1$  with spinules as well as hairs on dorsal surface;  $R_2$  with hairs on ventral surface; tuft hairs at base of radial vein dark brown except apical portions of hairs appearing yellow. Basal cell absent. **Abdomen.** Basal scale pale with pale long hairs. All abdominal segments light to medium brown

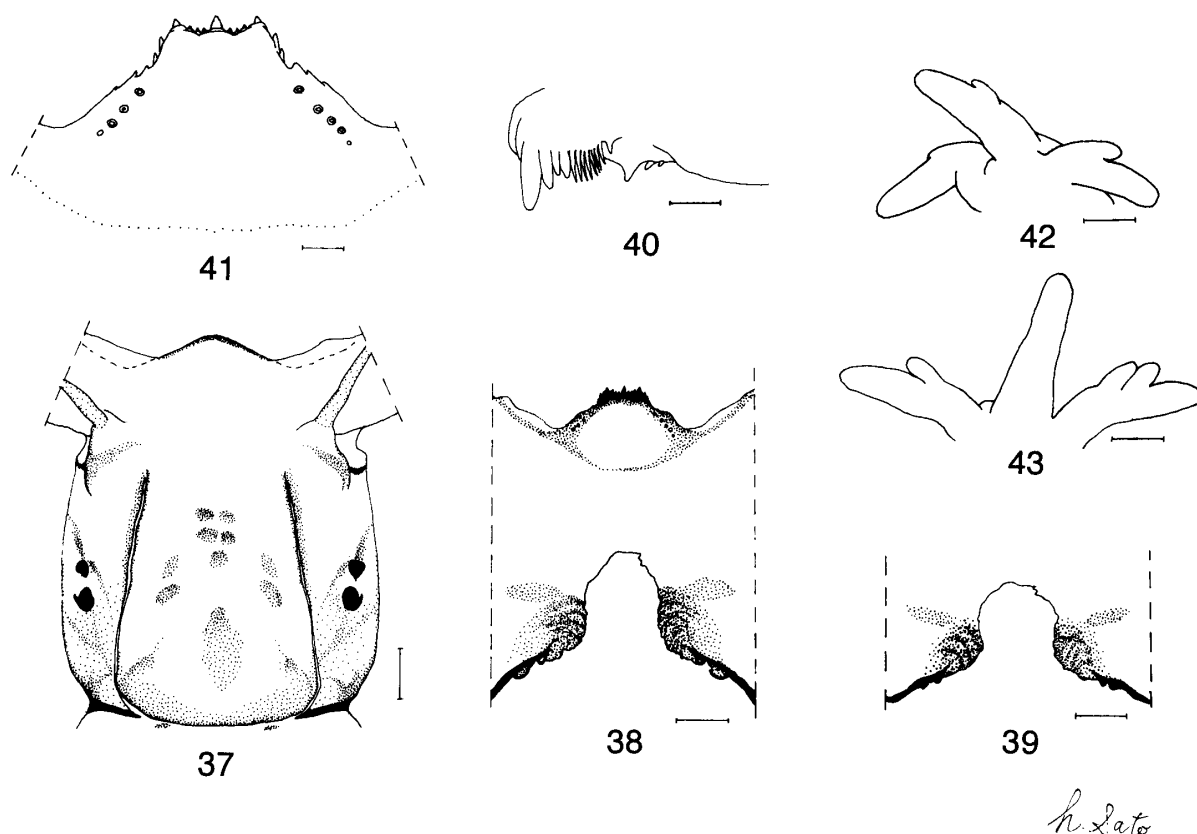


Figs. 30–36. Morphological characters of pupa of *Simulium (Nevermannia) artum* sp. nov. 30, right gill (dorsal view); 31 and 32, basal portions of gill filaments (dorsal view); 33, gill (showing enlargement of part of filament); 34, terminal hooks (dorsal view); 35 and 36, cocoons (35, dorsal view; 36, lateral view). Scales. 0.02 mm for Fig. 33; 0.04 mm for Fig. 34; 0.1 mm for Figs. 31 and 32; 0.4 mm for Fig. 30; 1.0 mm for Figs. 35 and 36.

except segment 2 pale, and moderately covered with short hairs on dorsal surfaces; all tergites not shiny; ventral surface of segment 7 with large sternal plate medially. **Genitalia.** Sternite 8 (Fig. 25) bare medially, with 13 or 14 stout hairs laterally on each side. Ovipositor valve (Fig. 25) nearly triangular, thin, membranous, densely covered with microsetae interspersed with 6 or 7 short hairs and 0–2 long hairs (except narrow portions along inner and posterior margins bare); inner margins slightly sinuous and weakly sclerotized. Genital fork (Fig. 26) of usual inverted Y-shape; arm rather wide, strongly folded apically, with wide projection directed posteromedially. Paraproct (Figs. 27 and 28) slightly produced ventrally, with 15 or 16 long hairs on lateral and ventral surfaces, and with 7 sensilla on inside surface. Cercus (Figs. 27 and 28) 1.6–1.7 times as wide as long, rounded posteriorly. Spermatheca (Fig. 29) globular, well sclerotized (except small area near its juncture to duct unsclerotized) and with distinct reticulate surface pattern; internal setae appear to be absent; both accessory ducts slender, slightly greater in diameter than major

one.

**Pupa.** Body length 2.5–3.4 mm. **Head.** Integument light yellowish-brown, almost bare; antennal sheath normal, with no spinous projections, and bare; face with 1 pair of simple long trichomes with coiled or uncoiled apex; frons with 3 pairs of simple trichomes (3 long with coiled or uncoiled apex). **Thorax.** Integument light yellowish-brown, almost bare on anterior 1/2, moderately covered with tubercles dorsally on posterior 1/2, with 3 pairs of simple long trichomes with coiled apex dorsally, with 2 pairs of simple trichomes (1 long and the other medium-long with coiled or uncoiled apex) anterolaterally, with 1 pair of simple medium-long trichomes with uncoiled apex posterolaterally, and with 3 pairs of simple trichomes with uncoiled apex (their lengths are short or medium, differing from one another) ventrolaterally. Gill (Figs. 30–33) composed of 4 long slender filaments arising independently at the same level from short common basal stalk (Fig. 31), or arranged in 2 pairs, each with short stalk (variable in length, with the longest subequal to the common basal stalk) (Fig. 32); all



Figs. 37–43. Morphological characters of mature larva of *Simulium* (*Nevermannia*) *artum* sp. nov. 37, head capsule (dorsal view); 38, head capsule showing bullet-shaped postgenal cleft (ventral view); 39, round postgenal cleft; 40, apical portion of mandible; 41, hypostomium; 42 and 43, rectal organs (42, thumb-like secondary lobules; 43, finger-like secondary lobules). Scales. 0.02 mm for Figs. 40 and 41; 0.2 mm for Figs. 37–39, 42 and 43.

filaments usually dark brown, closely lying (usually somewhat horizontally) near base, then directed downwardly and forwardly, almost the same in length (3.0–4.2 mm) and thickness, tapered gradually toward apical tip, with distinct annular ridges and furrows and densely covered with minute tubercles on their surface (Fig. 33). **Abdomen.** Dorsally, segments 1 and 2 light yellowish-brown and almost bare; segment 1 with 1 simple long seta on each side; segment 2 with 1 simple medium-long seta and 5 somewhat spinous setae submedially on each side; segment 3 light yellowish-brown on anterior 1/2, pale on posterior 1/2; segment 4 almost pale; segments 3 and 4 each with 4 hooks and 1 short spinous seta submedially on each side; segments 5–8 almost pale, each with distinct spine-combs in transverse row, together with comb-like groups of minute spines and 2 short spinous setae on each side; segment 9 with comb-like groups of minute spines, of which some developed to varying extents, appearing to be spine-combs (though much small-

er than those on segments 5–8); segment 9 also with a pair of distinct simple cone-like terminal hooks (Fig. 34). Ventrally, segment 3 with a few simple slender minute setae on each side; segment 4 with 1 simple hooklet and 3 simple minute setae on each side; segment 5 with a pair of bifid and trifid hooks close together submedially and a few simple short slender setae on each side; segments 6 and 7 each with a pair of bifid or trifid inner and simple or bifid outer hooks somewhat separated from each other and a few simple short slender setae on each side. Each side of segment 9 without grapnel-like hooklets. **Cocoon** (Figs. 35 and 36). Wall-pocket-shaped, light ochreous, tightly woven without open spaces in webs, extending ventrolaterally; anterodorsal margin thickly woven; 3.5–4.5 mm long by 2.0–2.9 mm wide.

**Mature larva.** Body length 5.2–6.0 mm. Body color whitish yellow, somewhat greyish or light yellowish in most larvae, though thoracic segment 1 brownish in some larvae. Abdomen narrower than thorax on segments 1–4 though

gradually broadened posteriorly, abruptly swollen from anterior to posterior margins of segment 5, broadest on segment 6 and gradually narrowed from segment 7 to segment 9. Cephalic apotome (Fig. 37) yellow, somewhat darkened near posterior margin; head spots light brown, well defined. Lateral surface of head capsule yellow except eye-spot region white; eyebrow light brown; all spots posterior to and ventral to eye-spot region faintly to moderately positive. Ventral surface of head capsule (Figs. 38 and 39) yellow, with light to medium brown long and small spots on each side of postgenal cleft; posterior margin heavily sclerotized as usual. Antenna much longer than stem of labral fan; proportional lengths of 1st, 2nd and 3rd segments 1.0 : 1.1–1.3 : 0.7–0.8. Labral fan with 28 or 29 main rays. Mandible (Fig. 40) with comb-teeth of different lengths (1st longest and 2nd shortest); mandibular serrations composed of 2 teeth (1 large, 1 small); large tooth at an obtuse angle with the mandible on apical side; 1 or 2 supernumerary serrations present. Hypostomium (Fig. 41) with 9 apical teeth in row; medial tooth subequal in length to each corner tooth, much longer than 3 intermediate teeth on each side; lateral margin moderately serrated apically; 4 or 5 hypostomal bristles per side, lying nearly parallel to lateral margin. Postgenal cleft small, bullet-shaped (Fig. 38) or rounded anteriorly (Fig. 39), ca. 1.0–1.1 times as long as postgenal bridge. Cervical sclerites (Fig. 37) composed of 2 small rod-like pieces, not fused to occiput, widely separated medially from each other. Thoracic cuticle almost bare. Abdominal cuticle almost bare except a few posterior segments sparsely (or moderately on segment 8) covered with simple colorless short setae on dorsal surface, and each side of anal sclerite of last segment (down to base of ventral papillae) densely covered with simple colorless short setae. Rectal scales distinctly discernible. Rectal organ (Figs. 42 and 43) simple, or compound, each of 3 lobes with 1 or 2 secondary lobules of various sizes. Anal sclerite of usual X-form, with anterior arms 0.7–0.8 times as long as posterior ones, broadly sclerotized at base; accessory sclerite and sensillum absent. Ventral papillae well developed, clearly visible. Posterior circlet with ca. 84 rows of up to 14 or 15 hooklets per row.

TYPE SPECIMENS. Holotype: Male (preserved in 70% ethanol), reared from pupa collected from a small stream at Senjyugahama in Nikko National Park, Nikko City, Tochigi, Japan, 26. VII. 1984, by Matsumura. Paratypes: 1 pharate male, 4 pupae and 5 mature larvae, same data as holotype; 1 male reared from pupa, and 1 pupal exuvia, same data as holotype except date, 24. VII. 1982; 2 mature larvae, same data as holotype except date, 27. V. 1987; 3 pharate females, 7 pupae, 7 pupal exuviae and 5 mature larvae (preserved in 70% ethanol) collected from upstream of Furu-ume dam, Bihoro town, Hokkaido, 21. VII. 1998, by Saito.

BIOLOGICAL NOTES. At Senjyugahama, Tochigi Prefecture, the larvae and pupae of this new species were attached to trailing grass leaves in a very small slow-flowing stream. Water temperature was 11.8°C when measured in May 1987. According to Saito (personal communication), immature stages of *S. artum* were collected from following streams of various localities: a stream (water temperature 16°C, altitude 1,460 m) at Yutaki in Tochigi in May, 1983; a stream (width 0.2 m, depth 0.1–0.15 m, water flow medium, water temperature 12.5°C, altitude 660 m) at Hanayama, Kurihara, and another stream (width 1.0 m, depth 0.1–0.2 m, water flow medium, water temperature 16°C, altitude 320 m) at Baba, Akiu, Taihaku, Sendai City in Miyagi in June, 1986; a stream (width 1.0 m, depth 0.05–0.1 m, water flow medium, water temperature 11°C, altitude 1,040 m) at Shomyo, Tateyama, Nakaniikawa in Toyama in August, 1986; a stream (width 1.5 m, depth 0.05–0.1 m, water flow medium, water temperature 10°C, altitude 1,560 m) at Myokoukogen, Nakakubiki in Niigata in August, 1992; a stream (width 0.5 m, depth 0.05–0.1 m, water flow slow, water temperature 15°C, altitude 1,240 m) at Kamitakara, Yoshiki in Gifu in July, 1994.

Associated species were *Prosimulium yezoense*, *S. iwatense*, *S. subcostatum*, *S.*

Table 1. Differences in several morphological features between *Simulium artum* sp. nov. and nine known Japanese species of the *vernum* species-group.

Features		<i>artum</i> sp. nov.	<i>acneria</i>	<i>boldstemta</i>	<i>bonninense</i>	<i>ono</i>	<i>larvipilosum</i>	<i>rebunense</i>	<i>subcostatum</i> s. l.	<i>uchidai</i>	<i>uemotoi</i>
Female and male	Katepisternum	Bare	Bare	Bare	Haired	Bare	Bare	Bare	Bare	Bare	Haired
	1st and 2nd segemnts of maxillary palp	Light to medium	Dark	Dark	Dark	Dark	Dark	Dark	Dark	Dark	Pale
Female	Projection of genital fork	Absent	Present	Present	Present	Present	Absent	Present	Absent	Absent	Absent
Male	Hair covering of ventral plate	Centrally	Centrally	Centrally	Almost entirely	Centrally	Centrally	Centrally	Centrally	Centrally	Centrally
Pupa	Number of trichomes on frons	3 long pairs	2 long pairs	2 long pairs	2 long pairs	2 long pairs	3 long pairs	2 long pairs	3 long pairs	3 long pairs	2 long and 1 short pairs
	Length ratio of gill against body	≥1	<1	<1	<1	<1	<1	<1	>1	≒1	>1
Larva	Anterodorsal projection of cocoon	Absent	Present	Absent	Absent	Absent	Absent	Absent	Absent	Present	Absent
	Number of secondary lobules per lobe	0-2	2	8	0	0	4-6	0	0-2	0-5	0
Larva	Postgenal cleft	Medium- sized, bullet- shaped, or rounded	Medium- sized, spade- shaped	Small, somewhat oval	Medium- sized, mitre- shaped	Medium- sized, spade- shaped	Medium- sized, mitre- shaped	Medium- sized, rounded	Medium- sized, rounded	Medium- sized, rounded	Small, M- shaped

\* References used for known species are Ono (1978; 1979), Okazawa (1984), Takaoka (1976), Takaoka et al. (1999), Sato et al. (2004).



*uchidai* and *Twinnia japonensis* in Tochigi; *P. yezoense*, *S. japonicum*, *S. konoii*, *S. subcostatum* and *S. uchidai* in Miyagi; *S. japonicum*, in Toyama; *S. japonicum* and *S. uchidai* in Niigata; *P. yezoense*, *S. aokii*, *S. japonicum* and *S. subcostatum* in Gifu Prefecture.

**DISTRIBUTION.** Hokkaido and Honshu (Gifu, Miyagi, Niigata, Tochigi, and Toyama) in Japan. The Prefectures are based on the following references: Saito and Kanayama, 1988; Saito et al., 1988; Saito et al., 1995a, b and 1996.

**ETYMOLOGY.** The species name *artum* refers to the characteristic arrangement of the pupal gill filaments which arise together at the same level from the short common basal stalk. The latin adjective "artus" means "close together". The Japanese name of this new species is Yoshidatsunomayu-buyu, as proposed by Orii et al., 1969.

**REMARKS.** *Simulium artum* sp. nov. is assigned to the *vernum* species-group by the male ventral plate (Figs. 11–13) lamellate and without median keel, style (Figs. 6 and 8–10) elongate with a large, broad, inwardly-twisted apex, paramere (Fig. 14) with a single hook, and median sclerite (Fig. 15) inverted Y-shaped; pupal gill (Figs. 30–32) with four slender filaments per side; and larval mandible with supernumerary serrations (Fig. 40).

This species is characterized by the pupal gill with four long slender filaments usually arising together at the same level from the very short common basal stalk (Figs. 31 and 32), which separates this species from all the known species of the *vernum* species-group.

Table 1 compares several major characters of *S. artum* with those of nine known species of the *vernum* species-group in Japan. This species appears to be most closely related to *S. subcostatum* in that it has a combination of the following characters; katapisternum bare, female genital fork (Fig. 26) without any projection direc-

ted anteriorly on each arm, pupal frons with three long trichomes on each side, cocoon simple (Figs. 35 and 36), and larval rectal organ (Figs. 42 and 43) with 0–2 secondary lobules on each lobe.

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